Relative Luminosity Measurement in STAR and Implications for Spin Asymmetry Determinations

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The simplified expression for extracting single and double spin asymmetries in polarized proton-proton collision is:

$$A_n = \frac{1}{P_{beam}^n} \left[\frac{N_- - R \cdot N_+}{N_- + R \cdot N_+} \right], \qquad A_n \equiv \begin{cases} A_N, A_L & \text{for } n = 1, \\ A_{TT}, A_{LL} & \text{for } n = 2, \end{cases}$$

where n=1(2) corresponds to single (double) spin asymmetry, and $N_{+(-)}$ are the spin dependent yields for different spin orientation of the beam(s) . It is therefore necessary to know from separate measurements the magnitude of the beam polarizations P_{beam} and the relative luminosity $R = L^+ / L^-$. For example, since the double (longitudinal) spin asymmetries A_{LL} are very small, of the order of a few per cent, statistical significance is achieved if $\delta A_{LL} \sim 10^{-3}$. The relative luminosity needs to be measured at the 10^{-3} level or better. This means that the statistical uncertainty on R as well as the spin dependence of the luminosity monitoring reaction must be small.

For transverse beam polarization, if the detector is left-right symmetric, the single spin asymmetries A_N can be determined without knowledge of the relative luminosity R. In this case, one can test the precision of the relative luminosity R determination by comparing the A_N results from two methods. Accurate measurement of R during the initial polarized proton run with transverse configurations of the proton spins is important in preparing for future measurements of A_{LL}.

In December 2001, the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory started colliding transversely polarized proton beams at $\sqrt{s} = 200$ GeV. The Beam Beam Counters (BBC) were newly installed and a crucial component of the STAR (Solenoid Tracker At RHIC) detector setup in the initial polarized proton run. The BBC consists of scintillator annuli mounted around the beam pipe beyond the east and west poletips of the STAR magnet. They cover pseudorapidities of $2.4 < |\eta| < 5.0$ and azimuthal angles of $0 \leq \phi \leq 2\pi$ with ϕ segmentation of about $\Delta\phi \cong \pi/2$. Coincidences between the counters on either side of the interaction region were used in physics triggers to reject beam-gas events. In addition, the BBC was used to monitor the beam luminosity L during the running period, and to measure the relative luminosities R.

The method and preliminary results of the BBC data analysis will be presented. Analysis of transverse single spin asymmetries and systematic effects are well underway.